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Abstract

Some Engineering Studies on the Analysis of Kinetics and Control of Tokai Atomic Power Station

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A series of analyses has been made on the kinetics, control and operational characteristics of the British type gas cooled reactors with positive temperature coefficient of reactivity. The preliminary analyses provided us with quantitative information on the transient response of the reactors of this type, as well as general conclusions on the stability of reactors with temperature and xenon feedback and the effect of the graphite sleeve on stability. Extensive investigations were made on the xenon-induced, spatial flux oscillations in the radial, azimuthal and axial directions. It was revealed that the conventional approach to simulate the reactor dynamic behavior was sometimes inadequate. Thus, investigations were made on the space dependent transfer functions of both the nuclear kinetics and the temperature transients. The transfer function representation of the space dependent nuclear kinetics proved to be a convenient means for the control system synthesis described below.

Stability and performance analyses of the temperature control system were made using the generalized Nyquist's criterion and Kochenburger s describing

function method. First of all, the conditions of stability as well as the optimum settings of the controller were obtained for conventional controllers. It was concluded that (1) the continuous system is unstable, when the controller gain is either too high or too low, (2) saturation in the control rod speed does not significantly affect the system response and (3) when discontinuous control is adopted, the system either diverges or undergoes sustained oscillations corresponding to the stable limit cycles. The effect of having the control rod position feedback on the controller was also examined. It was noted that the system with the rod position feedback showed increased stability and improved system performance compared to the conventional control system.

In order to control the xenon induced spatial oscillation, nine sets of controllers were assigned to each of the nine sectors of the core. A method was developed for synthesis of the non-interacting control between these controllers by means of unitary transformation of the transfer function matrix. In addition to general analytical results, analog computer solutions are presented to demonstrate non-interacting control.

The dynamics of the steam raising system and of the turbine-generator were also investigated. Transient variations in temperature and pressure of the system, subject to changes in the electrical load, were examined.

The dynamic behavior of the reactor during large power changes were studied. The maximum allowable rate of power change and the reactivity worth required for the control rods were obtained.

Analyses were made on start-up accidents, continuous rod withdrawal at power and loss of coolant accidents. They afforded necessary information on appropriate settings for the scram-levels.